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A COMPARISON OF THEORETICAL MODELS FOR PARAMETRIC OSCILLATOR DESIGN AND PERFORMANCE

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The design of high efficiency, high spectral purity optical parametric oscillators (OPOs) for long range remote sensing experiments requires theoretical models with accurate predictive capability. In this study we compare a suite of theoretical models which treat the physics of parametric oscillation at varying levels of approximation and differ from each other in their ability to handle questions about detailed spatial and temporal behavior or to conveniently address global questions regarding OPO "design space" and optimization.

The simplest model is based on the analytical theory of three wave mixing augmented by certain ad hoc assumptions to take into account finite temporal duration pump pulses, beam size, and beam quality effects. Formulated within a commercial scientific spreadsheet environment (TK), this model is useful for addressing questions about scaling and optimization, or for "back of the envelope" designs. The analytical model implicitly assumes a single carrier frequency for the pump and signal waves, and can treat spatial and temporal dynamic range effects only in an ad hoc manner.

The second model is a time dependent plane wave code which can handle pump pulses with arbitrary time dependence, and can be used to simulate multiple wavelength seeding. This code is useful for studying the generation of OPO pulses with complex, but deterministic spectral content. However, transverse spatial profiles and attendant walk-off and diffraction effects are not treated.

The third model is a nonlinear pulse propagation code based on the paraxial approximation to Maxwell's equations in a general birefringent crystal. Both arbitrary temporal and transverse spatial dependence of the pump beam is allowed, along with walk-off and divergence effects. Currently, these calculations are limited to a single carrier frequency for the pump beam and injected seed beam.

We compare the predictions of "test cases" where the assumptions of all three models agree as closely as possible: temporally square, top hat transverse profile pulses, large beams with negligible walk-off, and diffraction effects. We then systematically explore the deviations from the predictions of the analytical model caused by dynamic range, beam size, and beam quality effects encountered in real OPOs.

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